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[redacted] Jul. 1962 [redacted]

COLONEL [redacted] STUDY

NOT RELEASED

SATELLITE RECONNAISSANCE

The National Reconnaissance Program consists of Photographic, Electronic and Weather intelligence collection systems. This program has been operational for over a year ? and is presently furnishing considerable quantities of data on Communist Bloc nations to the Intelligence Community. It has been invaluable in obtaining intelligence on Soviet weapon s and radar sites, targets, and order of battle that has been unavailable from other sources. OMIT [Because of its broad national scope and application, importance, and sensitivity, and because of a need for maximum efficiency, its management has been centralized into the National Reconnaissance Office (NRO).]

To the maximum extent possible the operational, developmental and research aspects of the National Reconnaissance Program have been carried on concurrently. Developmental flights have been planned to obtain as much usable intelligence as possible and operational missions have been used to carry R&D experiments and tests. The capabilities of the systems have been constantly improved based on experience from previous flights and advances in ~~the~~ technology. An aggressive program of R&D for major improvement in collection capabilities is underway along with the important but less

[redacted]

impressive engineering modifications. Studies are constantly underway to define what new capabilities can and what should be started in the future to assure that we realize the maximum usable intelligence from this vital source.

The present National Reconnaissance Program does not, and its systems under development will not completely satisfy all of the valid requirements of the Intelligence Community. There are many obvious deficiencies [redacted] We are also vulnerable to political action. Our systems are certainly not as efficient as they could be and, as our collection capability increases, we must decrease the cost per unit area of coverage. Some of these deficiencies are inherent in the technology that we must deal with, but many improvements are within the capability of the present state of the art and many other improvements can be realized from well directed aggressive research followed by development. As in all weapon system programs we must have a proper balance between operations, development and research. We must start development now of the systems of the near future and we must conduct initial research that will permit developments for the more distant future. To do this intelligently and efficiently, we must define the deficiencies of the present program and pin point the needs of the future. Only in this way can we plan a reasonable program for the future.

Under each of the three categories of satellite reconnaissance--Photo, ELINT & Weather--we have stated the present capabilities, discussed the future requirements and capabilities of meeting these requirements, and finally discussed the impact of our needs and capabilities on the future National Reconnaissance Program.

No attempt has been made herein to completely justify or prove the requirements, to weight the relative importance of these various requirements or to assign priorities to them. This would have real significance only as it applies to a specific means of meeting the requirement and the difficulty, cost and timing of their accomplishment.

[redacted]

STAELLITE PHOTOGRAPHIC RECONNAISSANCE

I. PRESENT CAPABILITIES

Our photographic satellite program covers the highest priority and has furnished the most useful and impressive results. There are four active photographic projects, one presently inactive project and a group of research and study projects, as follows:

CORONA-MURAL - The CORONA-MURAL system is an operational system using the THOR-AGENA booster combination. It consists of two 24" focal length panoramic cameras using 70 mm film. These cameras can obtain about 4.5 million square miles of stereo coverage per mission. (?) Fourteen of 19 flights have returned material for exploitation with ground resolutions of up to about ten feet and an average ground resolution of between 10 and 20 feet. Fifteen missions are scheduled in the next twelve months. The present time required from request for a mission to delivery of film to the exploiters is About 25 ~~25-36~~ days (~~20-17 / 3 / 5~~).

An improved version of the CORONA system called the CORONA-J will almost double the film recovery capability of the system. A second recovery bucket has been added to the CORONA MURAL camera package so as to permit a total of 7-9 days of camera operation instead of 4-5 and thereby increasing the coverage to 6-8 million SQ MILES

[redacted]

(from 4.5). This improvement also permits the vehicle to go into an inactive, unstabilized mode for up to over 20 days between the time that the first and second recoveries take place. The first of the CORONA-J vehicles is scheduled to fly in early June 1933. This J configuration has been made possible by the improvement of the THOR booster to the Thrust Assisted THOR (TAT) version. Three solid rockets are fastened to the sides of the THOR giving about 650 additional pounds on orbit. The TAT was successfully operated ~~on~~ in ________ April 1933.

Improvements to the camera are underway to reduce sensitivity to temperature changes. This change will be effective in ___________ and should result in an improvement in the average resolution of the film of several feet.

Action is being taken to reduce the time required to prepare and launch a mission. A standby capability of [redacted] or less will be attained to permit the rapid replacement of an unsuccessful launch or to permit quick reaction to emergency situations.

LANYARD - The LANYARD system is expected to give a ground resolution of up to about five feet at 2:1 contrast. It is boosted by a Thrust Assisted THOR-AGENA combination and will orbit at between

[redacted]

110 and 130 nautical miles for four days. The 66" focal length panoramic camera will give about [illegible] million square miles of continuous coverage over a swath 40-50 miles wide. The [illegible] can [illegible] be [illegible] to [illegible] the [illegible] If the stereo mode is desired the coverage is cut in half and is intermittent. The first flight was unsuccessful due to booster failure. The next flight is scheduled for 16 May 1963.

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Page 7

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E-6. The E-6 camera was the payload instrument for the 722 System which was terminated last year. The system was based on two 36" focal length panoramic cameras. The design specification of the system was 84 lines/millimeter, which would result in 10 feet resolution at 123 nautical miles. The termination followed five unsuccessful flight tests, the last two being failures of the recovery vehicle which was a new design. CONTRIBUTING ~~Primary~~ reasons for the termination were a statement by NPIC last summer that the CORONA MURAL photography was all that was needed (which has since been changed), AND ~~coupled with~~ budgetary considerations.

[redacted]

The later E-6 cameras, of which there are four dual systems on hand, exhibited performance much better than that specified in the contract. These 100 line/millimeter systems would provide 6.6 foot resolution from 100 nautical miles.

Recently DNRO convened an Ad Hoc Committee representing the NRO Staff, the Directors, Programs A and B, and NPIC, to review and make recommendations for the system to succeed CORONA MURAL in the search role. This committee recommended that the E-6 camera be used to satisfy this requirement since further improvement to 120 lines/millimeter or better is possible and will provide 5.6 foot resolution and is available earlier than any other possible system. In addition the ATLAS AGENA booster combination permits considerably more film to be carried and gives a decided cost effectiveness to the E-6 system advantage.

A small effort has been maintained on this hardware and the four systems on hand could be flown beginning in September or October of this year with the current 162 recovery system. About February of next year, a larger recovery vehicle, which would be a scale up of the present vehicle, would be available as would the improved camera.

[redacted]

[redacted]

It is anticipated that by Mid 1964 this system could pick up the search mission in its entirety after a thorough flight test program. Each launched vehicle would obtain 12,300,000 square nautical miles in each of two missions (to be run as two 5-day missions a week apart) for essentially 200% coverage of the Sino-Soviet Bloc per launch.

③ **ARGON.** ARGON is an operational photographic system for geodetic and mapping purposes using the THOR AGENA booster. It consists of a 3" focal length frame type terrain camera of high geometric fidelity supplemented by 3" focal length stellar camera. The terrain camera capability is 6,000 photographs (235 x 23.5 nm format) its scale covering 166 million square miles in a four-day mission. Stereo is provided by overlap in the photographs. Positional accuracy obtainable from this photography alone is 750 feet HORIZONTAL ACCY AND 500 FT CONTOURS. ~~and contour accuracy is 1500 feet.~~ Combining ARGON photography with CORONA photography permits an improvement of positional accuracy to 50 FT HORIZ ACCY AND 300 FT CONTOURS.

?

The committee also recommended development of the M_2 Camera system.

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Page 11

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II. Future Requirements and Capabilities

1. Very High Resolution. We need to be able to resolve details on the ground that are less than [redacted] in size.

To provide a technical intelligence capability, a camera system must resolve a ground target of [redacted] or less. [redacted] Various studies conducted in the last few years disagree as to the exact requirement for a technical intelligence capability, but they have generally conceded that a ground resolution, as stated above, is required.

Our present CORONA MURAL capability of 10 foot resolution is inadequate, and even the 5 foot resolution expected of LANYARD and the [redacted] when realized, will not adequately satisfy the technical intelligence requirements. In order to accurately determine the capabilities of the Soviet weapons and other systems, we need the highest resolution that we can possibly achieve. [redacted]

As the Russian learns of our satellite photographic capabilities he can be expected to increase his efforts to camouflage and hide his important facilities and equipments. He will also attempt to confuse us by the use of decoys and dummies. Only by very high resolution photography can we reduce the effect of such efforts.

Our experience in Cuba has clearly demonstrated that the 2-5 foot resolution as obtained from the U-2 photography is inadequate to tell us all we need to know about certain critical areas. In Cuba we were forced to resort to low level photography to get the detail that was needed. This same type of capability is required from over the Soviet Union where low level aircraft missions are impossible. This very high resolution photography does not have to be able to cover great

[redacted]

expanses of the Soviet Union. Coverage of 5-10 miles square would appear to be adequate provided we can accurately point at previously identified target areas.

One of the problems associated with very high resolution camera systems is the problem of pointing the camera at a specific target. The camera system necessarily has a long focal length and with the available film widths the resultant coverage is very small. For example,

[redacted]

Another area requiring continual development is the area of controlling vehicle dynamics. The attitude (pitch, roll and yaw) must be maintained to very stringent tolerances (________) in order to insure coverage from long focal length systems. In addition, attitude rates must be carefully controlled for a camera system with a long focal

[redacted] [redacted]

[redacted]

length. Attitude rates in excess of 10 to 20 degrees per hour will cause image smear and will significantly degrade the quality of the photograph. To maintain these extremely small attitude rates, new techniques must be developed to sense the horizontal plane of the vehicle in inertial space and then to maintain the vehicle's attitude to this established reference system within very small limits and with very small rates.

It is necessary to compensate for the image motion at the film plane caused by the forward velocity of the vehicle and to a much lesser extent by Corollis Acceleration. With the present Mural system, compensation rates within 10% of the required values apparently are sufficient to prevent significant image motion, but with long focal length systems suitable for a technical intelligence, image motion compensation must be more accurate probably better than 1/2 of 1%. There are several methods available to determine an image motion and then to compensate for it, but development will be necessary to make these systems sufficiently accurate to allow photography of NECESSARILY HIGH ~~sufficient~~ quality for technical intelligence. Passive technology includes pre-programming of velocity and vehicle altitude parameters so that IMC can be accomplished during a photographic pass as a function of system time. Active methods would include real time velocity and altitude determinations by radar ranging or motion sensing technology includes Doppler techniques, etc.

Another area requiring extensive development is the area of lens design. One of the associated problems is the fact that long focal length systems require very large and therefore very heavy glass components which are necessary to insure satisfactory light gathering. There are also problems in designing diffraction limited lens systems, aligning optics within the lens system, and in building collimators of

[redacted] [redacted]

[redacted]

sufficient focal length and precision to calibrate and adjust these new optical systems. Further study is also needed in the development of catadioptric (combination reflector and refractor optics) necessary to accommodate long focal length systems within the physically limited space of a satellite vehicle.

Atmospheric limitations will become a INCREASING problem as resolution improves and will ~~probably~~ Possibly preclude ground resolution of better than one foot. There are many recent studies predicting what this atmospheric limitation will be, but insufficient data is available to predict precisely the ultimate capability achievable fromsspace.

The U-2 camera system operating at 70,000 feet altitude, provided photography with ground resolutions up to 1 to 2 feet which might well be approaching the atmospheric limits from high altitude. AT NADIR This aircraft photography from an altitude of 70,000 feet is above the major portion of the atmosphere where most of the attenuation of visible radiation occurs. The problems created by the atmosphere, including scintillation, shimmer, absorption, and scatter require further study.

~~Studies are being conducted on this problem but additional study certainly will be required.~~

It is apparent that as new camera systems approach the atmospheric and other limitations, their system size and costs will increase expontentially. It now appears possible to attain in the 1965-1966 time period practical satellite photo system having resolutions approaching [redacted] coverage.

Such a system in its simplest form might be possible using a TAT-AGENA Booster system, but to obtain stereo coverage and assure the

[redacted] [redacted]

[redacted]

maximum probability of success should use an ATLAS-AGENA combination. [redacted] conditions. This system could probably be available by early 1965. Development of four camera systems would cost [redacted] up to flight test.

A limited exploratory development of the specific critical components of [redacted] Studies are being accomplished in optics pointing, IMC and [redacted]

This system would weigh about 8000 lbs. or more and would probably require a TITAN III booster system. It could not be ready for operation prior to 1966.

[redacted] [redacted]

2. High Resolution Search. A need exists for a broad coverage search photo reconnaissance system capable of resolving objects on the ground of [redacted] feet on a side.

Our Cuban operations clearly demonstrated our inability to locate vital targets such as the SA-2 sites. There are several instances where Soviet radars were located with CORONA MURAL photography only after their approximate locations was determined by other means. The 6-7 foot resolution capability of the presently proposed E-6 or M-2 search systems will certainly be a big improvement in this regard, but even this will not meet all our needs. With camouflage, hiding and other means of deception the Soviet can prevent us from locating new targets unless we can do better than 6-7 feet. Up to some point, probably about 2-3 feet of resolution, the intelligence gained from photography will be directly proportional to the resolution obtained.

In addition, we have to consider the fact that the average resolution obtained from a photo system is quite a bit poorer than the optimum. CORONA-MURAL photography enables interpreters to detect 10 foot objects only 15% of the time, 30 foot objects 50% of the time, and 100 foot objects, 100% of the time. The unanswered question, that is critical to future requirements and developments, is a determination of the various factors that cause this wide spread. If the primary factors are natural, e.g. atmospheric perturbations or illumination, there is likely to be a wide resolution spread in all satellite photography. If the camera or the vehicle are primary factors, then other designs may provide much more consistent results.

Unfortunately, at this time we essentially have only one point on the curve, CORONA photography. The U-2 material was not

[redacted]

obtained concurrently with the CORONA material, and while the conclusion can readily be drawn that there is more intelligence in better resolution, no valid quantitative conclusions can be made. A better understanding of both the requirements and the physical limitations to satisfaction of these requirements will be obtained this spring and summer from the LANYARD [redacted] At the present time, however, it would appear desirable to be able to obtain U-2 quality search photography from a satellite.

The inherent characteristics of cameras wherein area covered decreases as resolution increases and the problem of orbiting, recovering processing and interpreting vast quantities of film make a high resolution search capability difficult and costly to attain and surely places a practical limit on such a system. This practical limit would appear at this time to be somewhere in the vicinity of [redacted] feet of resolution.

The improved E-6 system can provide 6 foot photography and cover the area of interest twice in one launch (25 million square miles per mission). It will do this in an economical (relative to current costs) manner using an ATLAS AGENA launch vehicle. This system could be flown by October 1963.

The LANYARD system presently under test will have a limited search capability of about one million square miles (40-50 nm swath width) with a five foot resolution using the TAT-AGENA booster. Using an ATLAS AGENA booster combination the coverage and efficiency could be increased, but even with two cameras the swath width would be small (100 nm mono and 50 nm stereo).

Moving up the better resolution scale and considering a system [redacted] the problems increase

[redacted]

greatly. A dual installation would require a bigger booster such as the TITAN II, and the difficulties of [redacted] would act to limit the swath width to something less than that of the E-6.

[redacted]

It would appear now that we could design and develop a 4-5 foot resolution search system, 150-180 nm swath width and at least 10 million square miles of coverage permission that could be boosted by the ATLAS/AGENA, that to go to 3-4 foot resolution such a system would require a TITAN II and to go to [redacted] foot would probably require TITAN III.

3. All Weather Capability. A need exists, particularly in emergency situations, for a capability to obtain coverage in spite of bad weather over the target.

Clouds, poor visibility and darkness over the target have severely limited our present photo reconnaissance. Even with the help of our weather satellite, clouds have restricted our interpretation of ____% of our CORONA-MURAL photography. (In routine circumstances poor weather has required the increase of coverage and more missions) In critical situations, however, where time is vital, delays could be very costly. Particularly in terms of Post Strike Assessment where weapons are withheld until the results of the first attack can be evaluated, we cannot wait for good weather to be able to assign targets to the 2nd strike. For this purpose we need an all weather system with a capability of at least 20-50 foot resolution.

An all weather capability would of-course be a desirable thing to have for all types of satellite reconnaissance. However, present and foreseeable technology limits such a system to radar techniques and radar does not give promise for resolutions as good as the present CORONA-MURAL system (10-20 feet). Until there is a major break through in the state of the art radar can only be considered for very special uses where low resolution (20-50 feet) is acceptable. Radar cannot be considered for a search system because of small area coverage, narrow bandwidth and low resolution. It does not look now to be suitable for looking at indicator targets in critical international situations. Even CORONA-MURAL photography is marginal for such purposes and it has twice more the resolution as the 20-50 feet expected from radar and 4 to 8 times the

[redacted]

[redacted]

[redacted]

Control System

[redacted]

4. Quick Reaction. A need exists to be able to react to emergency requirements for satellite reconnaissance in a matter of minutes.

During periods of tension immediately prior to a possible outset of hostilities the Intelligence Community needs coverage of certain targets to assist them in their attempt to assess the enemy's intention. During hostilities there are also strong needs for quick reaction for Post Strike Assessment. In such a situation it could be vital that photo coverage of certain indicator targets be obtained, recovered, processed and furnished to the interpreters in as short a time as possible. Our present capability is 25-36 days from selection of target to interpretation of film. This time is being reduced and can certainly be cut down drastically, but with present and planned systems, it will at best be a matter of days not hours!

Our present capability to react to an emergency situation and initiate, accomplish, recover, process and evaluate a mission is based on a summation of time factors.

Preparation for Launch	-	19 days
Collection of Photography and Recovery	-	4 days
Transportation of Film	-	1½ days
Processing of Film	-	3 days
Transportation from Processor to Evaluator	-	½ day
Total	-	28 days

To significantly improve the situation, we must reduce the time to do all of these steps and to get the time down to a few hours. This will be a very difficult if not impossible job. At best it will be costly.

Reduction of the time required to prepare for launch can be realized by:

(1) pre planned programs for emergency mission kept in readiness

(2) automatic check out equipment

(3) solid boosters

(4) product improvement of boosters and AGENA

Reduction of time for the collection of photography can be accomplished by reduction of the number of targets and careful selection of these targets' readiness location.

The time to take the pictures is determined by the number and location of the targets required to accomplish the mission. It is limited first by the requirement for daylight over the target area. This could cause a delay from "go" of over twelve hours depending on the time of the year, the time of "go" and the location of the target.

It is limited by the time for the satellite to pass over the targets required. If only a few targets are required and these can be selected such that they can all be covered on one orbit and if this special orbit can be set up then the time can be as small as about one orbit or about 1½ hours plus time from "go" to launch. If targets cannot be so selected as to be photographical on a single orbit, this time can be up to 60 hours plus time from "go" to launch.

The time to physically recover the target information is based primarily on the time required for the satellite orbit to reach the recovery area and the time required to transport the film to the processor.

[redacted]

The time for the satellite to reach the recovery area can vary from one hour to 243 (daylight, South to North, etc.) depending on the location of the recovery area and the orbit of the satellite. For a one or two pass mission from Vandenberg we can recover in the vicinity of our present location. If we have several launch and recovery locations this part of the recovery time could be reduced for other than one or two orbits.

The time for transportation of film from the recovery area to the processor is at present about 1½ days for air recovery (2 days for water recovery). This could be reduced by having the film removed from the capsule in Hawaii instead of at Sunnyvale and by special faster transportation procedures such as having a B-47 fly the film direct to the processor.

The processing itself would be reduced a bit in an emergency situation because we would have less film to process and there is some time that could be saved if the processing for emergency operation could be done at the exploiters facility in Washington. At best it would appear that by improved and more costly procedures we could reduce the reaction time for film recovery to a few days.

Another possible solution to the quick reaction problem is the use of readout wherein the photo is processed in the satellite, and transmitted to the ground by a wide band radio link.

Readout offers great promise for Post Strike Reconnaissance where the resolution required is low and the data link band width needed is small.

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[redacted]

Readout indicator targets is, however, limited by band width [redacted] This problem is made worse by the need for the satellite to pass within range of the readout station.

In order to get [redacted] type to the interpreter quickly we must have multiple stations. Even this requires several passes, and high quality ground communications to transmit the picture back to the interpretation center. Placing readout stations in the far north close to the Pole can improve the efficiency of the system, but it is still limited to a very few stereo pairs per day (stations at VAFB, New Boston, Kodiak and [redacted] would give about ten stereo pairs per day) wider band widths or multiple bands can improve the situation but still do not make readout a very desirable approach, and we still have the preparation for launch and photo collection times to contend with.

The use of satellites on orbit that could photograph the indicator targets on command would eliminate the preparation time delays but such satellites would be vulnerable and there would still be the time delay required to pass over the proper targets. Depending upon where the satellite was located when the need for emergency coverage arose, the time to get over the targets. Depending upon where the satellite was located when the need for emergency coverage arose, the

[redacted] [redacted]

time to get over the target would vary from one to over 60 hours. The maximum time to get over any target could be reduced by having several satellites on orbit properly spaced, but it could still take hours from command to be able to see the target, and such a system still has to be recovered or read out.

WEATHER IS A CONTINUING GATING ITEM IN PLANNING INDICATIONS MISSIONS

5. Increased Efficiency of Operation. A strong need exists to reduce the cost of satellite reconnaissance operations.

Satellite photography, though cheap in terms of area covered, is still very costly in terms of the overall operational requirement. The Sino Soviet land mass covers __________ square miles. The Intelligence Community has already identified over 300 individual targets for the [redacted] system alone. Regular search of this area and regular coverage of these and other targets added to the requirement for improved resolution add up to a lot of vehicles, boosters and launches. The satellite reconnaissance program now costs over [redacted] dollars per year. This cost will go up unless the satellite operations become more efficient. If the cost of this program is to be kept down to a reasonable level, we must be sure that we utilize the best combination of booster payload and recovery system to obtain maximum cost effectiveness. The major portion of the cost of the Satellite Reconnaissance Program goes for operations rather than R&D. This because the major part of the cost of any mission is for procurement, check out, launch and tracking and because the development cost of the boosters used (THORS, ATLAS and AGENAS) have already been paid. The NRP R&D costs are mainly for the development of payloads and for orbital and recovery vehicles. Because of this it may be economically desirable to consider the development of improved payloads, recovery vehicles and or the change to a more efficient booster system for increased operational efficiency even without increased sensor performance. It requires that we evaluate our projects from a cost effectiveness standpoint. Once a given photographic system is performing successfully, it becomes a quantity film collection operation where cost per unit coverage becomes important.

Carry to Summary

We cannot just consider the cost of a mission but must relate this cost to the quantity of coverage obtained.

The cost of photographing a square mile decreases as the capability of the booster increases. For example, the cost of MURAL stereo photography using the THOR-AGENA and one recovery vehicle, is about [redacted] per square mile for 7,000,000 square miles. The cost, using the Thrust-Assisted THOR-AGENA and two recovery vehicles, will be about [redacted] per square mile for 14,000,000 square miles. [redacted] Costs are [redacted] per flight respectively.

It is, of course, self evident that coverage of one particular square mile may be worth far more than coverage of another particular square mile. It is also evident that there is no value in additional coverage capability during that period.

The two missions for one launch concept which is soon to be employed in MURAL, and is being studies for [redacted] and was recommended for the [redacted] enables us to make a more effective use of the capability of the boosters involved. Beyond this it appears probable that for some purpose, the use of several recovery vehicles will usually increase efficiency of operation. It is desirable to have more than one size of recovery vehicle so as to be able to assure maximum use of on orbit weight capability and maximum flexibility of operation. Evaluation of the [redacted] will appreciably increase the cost effectiveness of the system such that the reentry vehicle development cost would be paid for in a few missions.

It is apparent that the most economical size of recovery vehicle to use is one just capable of holding the film from one mission. If two or more missions are to be accomplished from one launch, one recovery vehicle should be carried for each mission. This scheme is the best compromise from the operational viewpoint between recovery force activity and customer desires for daily returns.

If requirements for very much better resolution search are to be satisfied, the boosters involved will, of necessity, be larger, i.e., TITAN II or TITAN III, in order to either boost the larger payload into orbit or to maintain a reasonable cost effectiveness. Probably the optimum system from a cost effectiveness standpoint alone would be one using the full boost capacity of TITAN III with a large number of recoverable vehicles on board at launch so that a corresponding number of missions could be accomplished for each successful launch. Of course, this presupposes a reliability not yet attained in space systems.

The efficiency of the NRP can also be increased considerably by the realization of interchangeable payloads (vehicle in front of the booster). This would provide the greatest operational flexibility to meet changing requirements and would require that fewer boosters would have to be stockpiled. This approach has been applied in part to the THOR-AGENA launches to date but much more interchangeability and standardization is possible.

6. Decreased Vulnerability. A very vital need exists to reduce drastically the vulnerability of our reconnaissance satellites to enemy nuclear attack.

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Pages 31 - 37

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8. Special Sensors. There is a need to develop additional sensors to improve our evaluation capabilities.

Normal photography, recording in the visible portion of the spectrum, will undoubtedly be continuously improved in the future with advances in lenses, films, vibration damping, stabilizing vehicle dynamics, etc. There are, however, physical limitations imposed upon this type of photography. These limitations would include the absorption and scatter of radiation by the atmosphere, insufficient lumination at night, and the problem of cloud coverage, haze and fog.

[redacted]

High-resolution radar could provide a nearly all-weather and night capability. The present state-of-the-art does not provide HRR of sufficient resolution to be used for search surveillance and significant development is required to accomplish even a Post Strike Assessment capability from satellite altitudes. The all-weather and night capability of radar makes this portion of the electromagnetic spectrum most worthy of continuing study.

[redacted]

Handle Via [redacted]
Control System

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Light intensification techniques are required to permit night photography. Other developments that would help achieve night photography would include, faster films, larger aperature lenses and light amplification electronics. Developments such as the Aeroflex/Delft laser illumination system should be continued. A good aircraft capability must be achieved before any satellite development can be programmed.

A capability is needed in multi-band or spectral zonal image forming sensors. The photo interpreter at the present time has available to him a panchromatic black and white photograph from which he obtains his information. If several photographs were available each imaging the same ground area in a different portion of the spectrum, more information would be available to the photo interpreter. New techniques in collection and exploitation of multi-band photography would require development and exploitation equipment and training for the interpreter. These techniques will probably aid the interpreter in camouflage detection and would increase the information content of the photographed area.

Color film is capable of providing increased informatinn, but has been little used in the past because of problems associated with the slow speed of color film, graininess of the emulsion, high costs and processing delays. Recent experiments in aerial color photography utilizing new films of increased speed and fine granularity have proven successful in proving the point that, with the same speed and granularity, color film provides more information to the interpreter than the same scene recorded on a panchromatic film. Further experiments should be conducted in aircraft and satellites. A few hundred feet of color film could be spliced at the end of mission supply spool and would provide very valuable data.

[redacted] [redacted]

9. Improved Flight Data. A need exists to develop a method of providing Camera Flight Data that is more accurate, more complete, and in a standard format suitable for expeditious utilization with the photography.

The photo interpreter in his analysis requires more than just a high quality photograph. The interpretation process requires that the interpreter have certain quantitative information about the size of objects. How big is the object - how hight - how far from town and in what direction, etc. These questions can be answered when a way is established to determine object coordinates from image coordinates. The traditional methods of obtaining dimensions, etc., from the unknown objects association with objects of known size, is not always possible, is not as accurate, and is not conducive to error analysis. To obtain object dimensions from image dimensions three types of data are needed:

Space location (Lat., Long. Alt.)
Attitude of camera (pitch, roll, yaw)
Calibrations (IMC, Time,) etc.

A requirement for rapid and accurate quantitative information from photography has prompted an increased utilization of analytical photogrammetric techniques, new associated satistical methods, and increased digital computer capabilities. One must consider the word "graph" in photograph. A picture becomes a graphic presentation suitable for quantitative analysis when sufficient flight data is provided with the photograph to insure accurate mensuration. Flight data must accompany all photographs, and development is required in improving the accuracy of this data, standardizing formats. etc.

[redacted]

The methods most commonly used to determine the attitude of a vehicle/camera system have included photographing the horizon, [redacted] [redacted] and stellar photography. Development should continue in inertial techniques.

New techniques must be established for determining relative orientation between the vehicle and aerial camera systems and between individual cameras. All lenses must be more carefully calibrated. A method must be developed to provide accurate data bout the physical dimensions of the film platen so that useful film shrinkage studies can be made. THE STUDY BEING CONDUCTED BY [illegible] [illegible] OF INERTIAL NAVIGATION SYSTEM SUCH [illegible] PROVIDE DATA FOR CAMERA ATTITUDE IS [illegible] AT [illegible].

Finally, development is needed to determine the best method of providing all camera flight data to the P.I. The present techniques of alpha-numeric or binary data blocks might be less efficient than storing this flight data on auxilliary magnetic tape or on a "sound strip" on the edge of the film.

In order to improve the accuracy of the camera location at the instant of exposure, it will be necessary to compute more precise ephemerides. Improvements could be effected by increasing the number of tracking stations, optimizing their location, developing new radar and optical tracking techniques establishing better atmospheric drag modesl, learning more about gravitational harmonics, etc. It also will be necessary to develop methods of providing an error analysis of all data. Intertial navigation systems can be used on space vehicles to improve location determining capabilities. New methods of stellar-inertial and radio-intertial techniques should be investigated.

[redacted]

Handle via [redacted]
Control System

[redacted]

10. Requirement for Man in Satellite Reconnaissance.

Satellite reconnaissance is one of the often cited reasons for man in space. The NRO has concluded that man has little utility in space reconnaissance systems in the roles of mission director, camera operator, or major decision director. These functions can best be accomplished on or from the ground. There are some areas, however, in which a man might perform some useful function. These areas will be discussed in this section, but no recommendations will be made as to future developments for man in space directed specifically toward satellite reconnaissance. Such recommendations must await a good deal more experience in both satellite reconnaissance and manned space flight.

It is readily apparent that carrying both man and useful camera systems in a long lived vehicle will require thrust capabilities no less than that of TITAN III.

A man might well be of value in early recovery, by readout, of photography of critical targets to obtain crisis type indicators. For example, high resolution photography might be processed on board by the web technique employed in E-2. There would necessarily be areas covered by the photograph that were not of interest. The severe band

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width limitation could be overcome by having the man select only those parts of the photograph which covered targets he had been told were of interest and transmitting only those portions of the photograph. It should be noted in passing that a beam splitting prism could be employed so that two negatives could be exposed at the same time. One of these could be physically recovered for optimum processing.

A man might be of assistance in the pointing problem. He could possibly fix on an initial point, much as a bombardier might do, to take out the uncertainties associated with knowledge of the ephemeris.

A long-lived system might have a multiplicity of small capsules for film recovery. One of the problems associated with this concept of early recovery is the threading of film through several capsules before it gets to the one in which it will be recovered. A man might help solve this problem.

There might be some limited maintenance that could be performed on board, and the man could possibly be of use in overcoming improper action of automatic focus or exposure controls.

He might also be able to determine the weather conditions over the target area and adjust exposure for optimum performance in the

[redacted]

shadows when partial cloud cover was present and normal automatic exposure devices would be confused by the light reflected from the clouds. He could also determine whether weather required recoverage of certain targets on the same mission.

[redacted]

[redacted]

18. Mapping, Charting and Target Material Collection. The ARGON and the Stellar Index (S/I) program represents the current capability for the collection of mapping, charting and target materials date. Each individual satellite provides through its ephemeris data an improved set of parameters for better definition of the geoid. The long line ~~[illegible]~~ bridging available from the data reduction of ARGON provides a most precise definition of the geoid. The S/I when combined with other photography through an analytical photometric technique provides data of a quantity capable of making provisional maps, charts and providing target materials.

The ARGON product when combined with its automatic data reduction system is providing maps with accuracies of 750 ft. horizontally and 600 ft. contours with respect to the DOD 60 WGS. The ARGON product when combined with CORONA product and the data reduced through the analytical photometric tehcnique provides provisional maps with accuracies of 50 ft. horizontally and 300 ft. contours. These accuracies are considered adequate to satisfy today's ballistic missile requirements and have been stated to be inadequate for low level aircraft penetration. The S/I product when combined with the CORONA product is providing horizontal accuracies of 740 ft. and contour accuracies of 600 ft. with respect to DOD 60 WGS and accuracies of 50 ft. horizontel and 300 ft. contours for the provisional maps.

The DIA has proposed to USIB (COMOR) a new statement of the requirement for geodetic and mapping data.

- - - - Photometric quantity photography of the world's land mass to (1) permit positioning of targets to an accuracy of 450 ft. (90% assurance) and - - - - elevation data at the target to an absolute

[redacted] [illegible] [redacted]

accuracy of 450 ft. with relative elevation within a radius of 90 miles of the target accurate to 10 ft. (2) automatic stereo comparison of standard topography maps at 1:50,000 scale with 30 ft. contours intervals with features accurate to 15 ft. vertically and 83 ft. horizontally relative to other features on the same sheet.

Horizontal accuracies greater than 416 ft. do not appear valid since the smallest line on a 1:250,000 scale map is 416 ft. wide. The 1:50,000 scale map does not appear reasonable for world wide coverage or even the Sino Soviet land mass. It is possible that the coverage required could be provided in the peripheral areas by aircraft and the ~~defined~~ denied areas by an improved satellite system.

The current state of the art will satisfy all of the known statements of requirements with the exception of the 1:50,000 scale contour data. A new ARGON type system will require on the order of two years for operational use. There exists six satellite mapping cameras that could satisfy the majority of the requirements.

The NRO recommends that the improved S/I plus pan system provide the data necessary for satisfaction of the mapping, charting and target materials requirement. The geodetic requirement has been very nearly satisfied by the two ARGON successes. In order for the S/I pan system to satisfy this requirement, USIB (COMOR) will have to specify operation of the system in all of the areas of interest (other than Sino Soviet Bloc only).

WEATHER INTELLIGENCE

I. PRESENT CAPABILITIES

The satellite weather reconnaissance program is presently operational and has for almost a year been supplying weather data of the Sino Soviet land mass for use in scheduling the operation of our photographic satellites. The data derived has been used to feed into the overall world weather prognostication and has been of great use to other users such as SAC. However, the NRO interest in weather satellites is and has been undertaken primarily to satisfy a need of the satellite photographic reconnaissance program.

417 Weather Satellite. Project 417 is a small weather satellite that provides daily cloud cover information of the area of interest in direct support of the forecasting activities which support the satellite reconnaissance program. The 417 space vehicle weighs 100 pounds, and is spin stabilized in a 400-mile orbit. Through magnetic tape recording of a video image, vertical cloud cover pictures of about one-mile resolution will be provided to readout stations at Vandenberg AFB and New Boston, N.H.

The first successful launch was accomplished 23 August 1962, the payload achieved an excellent orbit with apogee of 463 nm and perigee of 340 nm. All the systems have operated satisfactorily for over six months. A second vehicle is presently on orbit but internal difficulties have greatly reduced its useful output. An additional vehicle was launched in April but failed to orbit due to the failure of the Scout Booster.

An emergency direct readout station was set up at Eglin AFB on 28 October to support the Cuban operation. A van mounted mobile station is being built that will permit direct readout from any location to meet such emergencies in the future.

II. FUTURE REQUIREMENTS AND CAPABILITIES

The present 417 system is capable of meeting the NRO requirements in terms of quality. However, the reliability of the present system leaves much to be desired. The Scout Booster has proven unreliable (50%) and inexact in orbital placement.

There is also a requirement figure the users of the weather data to have two vehicles orbitting at the same time on complementary orbits.

Evaluation is presently underway to determine the best way to correct the reliability problem. One possibility would be to go to a somewhat larger vehicle so as to be able to have redundancy of payload components. This would require the THOR booster which would in addition correct the booster reliability and permit accurate placement.

Ultimately it is hoped that a national weather satellite or a DOD weather satellite will become a reality and NRO can obtain its required weather data from normal military weather sources.

III. WHAT SHOULD BE DONE

Based on the foregoing requirements and capabilities there are certain actions that should be taken now if our NRP is to progress with the technology and if it is to meet the needs of the users.

Photographic Payloads

1. Activate the [redacted] as a replacement for the CORONA MURAL. It will have better resolution and greater coverage with a more favorable cost effectiveness.

2. Initiate the long lead time parts of the Itek M-2 camera system as a back up for the [redacted] and continue until the [redacted] demonstrates its capabilities.

3. [redacted]

4. Continue the VALLEY limited exploratory high resolution camera development at about their present level of effort.

5. This fall after some LANYARD and [redacted] photography has been obtained and evaluated, initiate studies to define more clearly what is needed and what is capable regarding high resolution search.

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6. [redacted]

7. [redacted]

Boosters

1. The boosters presently available, THOR, ATLAS and TITAN II, appear adequate for our present purposes with three possible exceptions:

[redacted]

High resolution search - 2-3 feet

Man in space reconnaissance - does not in itself justify going to TITAN III

[redacted]

No action appears justified regarding TITAN III until the above items have had more study.

2. Initiate a program to reduce and simplify the system preparation for launch time - particularly the time required for program preparation.

Stabilization and Guidance

1. Initiate a development program for a long life on orbit stabilization system utilizing the stabilite principle for the SIGINT payloads.

2. Continue to improve the stabilization capabilities of the AGENA vehicle to assure their compatibility with the very high resolution cameras.

3. Continue the development of the UAC Space Navigator for use with very high resolution pointing optics, maneuvering systems and with lifting reentry land recovery systems.

Reentry Vehicles

1. Initiate development of the larger MARK VIII recovery vehicle to increase efficiency of operation.

2. Evaluate the need for and optimum size for a small recovery vehicle for quick return of the first one or two orbits' "take" in an emergency system.

3. Reactivate the program for development of a land recovery capability and maneuvering reentry capability and maneuvering reentry

of relatively small (200-1000 lbs.) capsules.

Man in Space

The requirement for man in space to support the reconnaissance program is limited and does not justify further action until more is learned about man's capabilities and support requirements in space and until we see and learn more about the capabilities and limitations of our new photographic systems such as [redacted]

Miscellaneous

Request USIB to initiate a study into the detailed requirements of indicator targets.